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(54) Title: <b>POLYAMIDES HAVING IMPROVED COLOR AND PROCESSIBILITY AND PROCESS FOR MANUFACTURING</b>			
(57) Abstract  Incorporation of certain phosphorus compounds in conjunction with certain bases into a polyamide melt or a polyamide manufacturing polymerization process results in a polyamide having improved color properties.			

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TITLE

POLYAMIDES HAVING IMPROVED COLOR AND  
PROCESSIBILITY AND PROCESS FOR MANUFACTURING  
CROSS REFERENCE TO RELATED APPLICATION

5        This application is a continuation-in-part of pending prior application  
Serial No. 08/019,388, filed February 18, 1993 and entitled Polyamides Having  
Improved Color and Processibility and Process for Manufacturing.

BACKGROUND

10       This invention relates to polyamide resins having improved color and  
processibility and a process for manufacturing these resins. The polyamide resins  
prepared in accordance with the process of the present invention are particularly  
useful in molding and extrusion applications and are manufactured in the presence  
of certain phosphorus compounds in conjunction with certain bases.

15       An object of the present invention is to provide polyamide resins which  
initially appear less yellow than the same resins having not been manufactured in  
accordance with the present invention. A further object of the present invention is  
to provide polyamide resins which undergo a lesser degree of color build-up (i.e.,  
increase in yellowness) on storage as compared to the same resins having not been  
manufactured in accordance with the present invention. Furthermore, an object of  
20       the present invention is to provide polyamide resins which do not undergo  
significant molecular weight increases during subsequent melt processing  
operations.

It is generally known that when polyamide resins are manufactured  
according to conventionally known processes without the addition of conventional  
25       pigments, these resins tend to exhibit varying degrees of yellowness in initial  
color, with said yellowness increasing over time. The resins also generally exhibit  
increased yellowness when exposed to high temperatures during subsequent melt  
processing operations. For example, during molding and extrusion applications, a  
certain amount of the resin is subjected to repeated melting in the form of regrind,  
30       which generally results in the molded or extruded resin exhibiting increased  
yellowness. Therefore, considering the extended storage time for some of these  
resins and the repeated melting during molding and extrusion, there exists a need  
to provide a process for manufacturing improved polyamide resins which initially  
appear, and continue to appear over time, less yellow than the same resins not  
35       prepared in accordance with the present invention.

Polyamide resins and their preparation are well known in the art. They can be obtained, for example, by self-polymerization of monoaminomonocarboxylic acids, or by reacting a diamine with a diacid in substantially equimolar amounts. It is understood that reference herein to the amino acids, diamines, and dicarboxylic acids is intended to include the equivalent amide-forming lactam derivatives thereof. Representative dicarboxylic acids include, for example, adipic acid, azelaic acid, pimelic acid, suberic acid, sebacic acid, dodecanedioic acid, isophthalic acid, and terephthalic acid, while representative diamines include, for example, hexamethylenediamine, octamethylenediamine, tetramethylenediamine, 2-methylpentamethylenediamine, decamethylenediamine, and dodecamethylenediamine. Representative amino acids include 6-aminocaproic acid, 11-aminoundecanoic acid, and 12-aminododecanoic acid. For purposes of this patent application, the above-identified compounds shall be referred to as "polyamide-forming reactants" and this term shall include combinations of the compounds, as well as individual compounds, provided the combination or individual compound can be polymerized to form polyamides.

It has now been observed that improved color (i.e., reduced yellowness) can be attained in polyamides by using certain phosphorus compounds. The phosphorus compounds serve as color stabilizers for the polyamides by reducing the degree of oxidative and thermal degradation. However, these phosphorus compounds also serve as polymerization catalysts and in addition, some serve as nucleating agents, as in U.S. Patent No. 4,237,034. Nucleated polyamides generally have lower toughness compared to polyamides which have not been nucleated and thus, phosphorus compounds which function as nucleating agents are not particularly desirable in applications where a loss in toughness is not desired. To the extent that the phosphorus compounds act as polymerization catalysts, polyamides containing these phosphorus compounds, when remelted in an extruder or molding machine, undergo rapid polymerization resulting in molecular weight (RV) increases, particularly when the remelting is done under conditions of low moisture. These molecular weight increases consequently result in decreased melt flow of the polyamide in a molding machine or other apparatus. In molding and extrusion applications, generally, this decrease and change in melt flow of the polyamide is undesirable.

In the present invention, it has been found that the catalytic effect of certain phosphorus compounds on a polyamide polymerization process can be reduced or stopped completely by the addition therein of certain bases without

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significantly and adversely affecting the phosphorus compound's desired effect of reducing resin color. The degree to which the phosphorus compound, acting as a catalyst, is deactivated depends on the amounts of phosphorus and base added to the polymerization process or to the polyamide melt. For economical and efficient processing, some degree of catalytic effect is desired for increased throughput, especially when polymerization is conducted by a continuous mode process, which is, generally, a kinetically limited process.

#### **SUMMARY OF THE INVENTION**

A process has now been developed wherein certain phosphorus compounds, in conjunction with certain bases, are incorporated into polyamides either during the polymerization process or after, within the ranges described herein, resulting in polyamide resins that not only exhibit improved initial color and color stability on storage, but that also do not undergo significant molecular weight increases during subsequent melt processing operations, as compared to polyamide resins prepared without these phosphorus compounds and bases. Polyamide resins made by the process herein are useful in numerous molding applications (i.e., automobile parts, mechanical parts, electrical and electronic parts, molded gears, sports equipment, appliances, etc.) and extrusion applications (i.e., tubing, rods, filaments, films, etc.).

#### **DETAILED DESCRIPTION OF THE INVENTION**

The present invention relates to a process for manufacturing polyamide resins, said resins being particularly useful in molding and extrusion applications. The polyamide resins prepared in accordance with the process of the present invention, as compared to polyamide resins not so prepared, exhibit improved initial color (i.e., reduced yellowness) and color stability on storage. Furthermore, the polyamide resins prepared in accordance with the process of the present invention do not undergo significant molecular weight increases during subsequent melt processing operations.

More specifically, the process of the present invention comprises polymerizing polyamide-forming reactants in the presence of certain phosphorus compounds in conjunction with certain bases. Alternatively, the process of the present invention comprises compounding into a polyamide melt certain phosphorus compounds in conjunction with certain bases. Polymerization processes are well known and can be, for example, batch or continuous mode processes. The polymerization processes contemplated by the present invention are those processes generally used to manufacture well known polyamides, such

as nylons 6, 11, 12, 66, 69, 610, 612, and their copolymers from well known polyamide-forming reactants. The preferred polyamide-forming reactants to be used in the process of the present invention are those polyamide-forming reactants generally used to manufacture nylons 6, 66, 610 and 612.

5           The phosphorus compounds used in the process of the present invention, and their preparation, are well known in the art. These phosphorus compounds serve as color stabilizers and polymerization catalysts in nylons. They include phosphorous acids, their salts, and their organic esters. Examples of the phosphorous acids include hypophosphorous acid, orthophosphorous acid,  
10   pyrophosphorous acid, and diphosphorous acid. The phosphorous acid salts useful in the present invention include salts of Groups IA and IIA, manganese, zinc, aluminum, ammonia, and alkyl or cycloalkyl amines or diamines. Examples of the organic esters useful in the present invention include mono-, di-, and triesters of phosphorous acid. The organic esters useful in the process of the  
15   present invention do not have direct carbon-phosphorus bonds so that in the presence of water, said esters undergo hydrolysis and are converted to inorganic phosphorus acids or their salts. Hydrolysis of phosphorus esters containing carbon-phosphorus linkage produces organophosphorous acids or their salts. Metal salts of these organophosphorous acids generally act as nucleating agents in  
20   nylons (U.S. 4,237,034), which can result in an undesirable reduction in polymer toughness. The preferred phosphorus compounds for use in the process of the present invention are hypophosphorous acid, orthophosphorous acid, diphosphorous acid, and their respective salts. Sodium hypophosphite (SHP) is the most preferred phosphorus compound.

25           The above-described phosphorus compounds are added in an amount sufficient to constitute concentrations ranging from 0.097 to 1.582 mols phosphorus (in the phosphorus compound) per million grams polyamide, preferably from 0.194 to 1.129 mols phosphorus (in the phosphorus compound) per million grams polyamide. Although the phosphorus compound can be  
30   introduced at any point prior to, during, or after polymerization, it is preferable to add the phosphorus compound as early as possible (i.e., pre-polymerization).

          The bases used in the present invention serve as phosphorus catalyst deactivators, thereby significantly reducing any undesirable increase in the molecular weight of the polyamide during subsequent melt processing operations.  
35   For economical and efficient processing, it may be desirable to only partially deactivate the catalyst, particularly for increased manufacturing throughput, and

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especially when polymerization is conducted by a continuous mode method. The degree of phosphorus catalyst deactivation may be controlled by the amount of base present.

The base is introduced into the polymerization process, or alternatively  
5 into the polyamide melt, in an amount ranging from 1.785 mols to 33.325 mols base per million grams polyamide, preferably from 3.571 to 14.286 mols base per million grams polyamide. The bases useful herein are well known in the art and include bases of Group IA, such as hydroxides, oxides, carbonates, bicarbonates,  
10 alkoxides, and hydrides. The preferred bases are sodium bicarbonate, potassium bicarbonate, potassium hydroxide, and sodium hydroxide, while sodium bicarbonate and potassium bicarbonate are the most preferred bases.

As stated above, the preparation of polyamides by polymerization processes can occur by generally known methods, such as a batch method or a continuous mode method. For example, in a conventional batch method, typically  
15 a 40-60% polyamide salt solution formed from equimolar amounts of diacid and diamine in water, is charged into a preevaporator vessel operated at a temperature of about 130-160°C and a pressure of about 35-100 psia, wherein the polyamide salt solution is concentrated to about 70-80%. The concentrated solution is then transferred to an autoclave, wherein heating is continued as the pressure in the  
20 vessel rises to about 160-600 psia, generally 195-300 psia. Additional water (steam) is allowed to vent until the batch temperature reaches about 220-260°C. The pressure is then reduced slowly (about 60-90 minutes) to about 15-1 psia. The molecular weight of the polymer is controlled by the hold time and pressure at this stage. Salt concentration, pressure, and temperature may vary depending  
25 on the specific polyamide being processed. After the desired hold time, the polyamide is then extruded into strand, cooled, and cut into pellets.

In this batch process, the phosphorus compound and the base can be added before polymerization (i.e., into a solution of at least one polyamide-forming reactant), or can be introduced at any point during polymerization, or can  
30 even be introduced post-polymerization (i.e., by incorporating the phosphorus compound and the base into a polyamide melt, using conventional mixing equipment, such as an extruder). The phosphorus compounds and bases can be introduced separately or all at once. However, for best results, and especially for protection against oxidation and thermal degradation, the phosphorus compound  
35 and the base should be added as early as possible in the polymerization process,

preferably at the beginning of the polymerization process. Additionally they can be added in solid form or in the form of aqueous solutions.

Continuous polymerizations are also well known in the art (See U.S. Patent 3,947,424). For example, in a typical continuous mode method, the  
5 polyamide salt solution is preheated in a preheater vessel to about 40-90°C, then transferred into a pre-evaporator/reactor where the salt solution is concentrated at about 195-300 psia and about 200-260°C to about 70-90%, resulting in a low molecular weight polymer. The low molecular weight polymer is then discharged into a flasher, where the pressure is slowly reduced to below 15  
10 psia and then discharged into a vessel maintained below atmospheric pressure and at a temperature of about 270-300°C to effect removal of water and to promote further molecular weight increase. The polyamide melt is then extruded into a strand, cooled, and cut into pellets.

As in the batch method, the phosphorus compounds and bases can be  
15 incorporated at any point during the process, including post-polymerization (i.e., by compounding them into the polyamide melt, etc.). However, for maximum antioxidant and thermal protection, it is recommended that the phosphorus compounds and bases be added prior to polymerization or as early as possible.

Additionally, it is understood that the polyamides prepared by the  
20 process of the present invention may also contain conventional additives such as flame retardants, lubricants, pigments and dyes, optical brighteners, organic antioxidants, plasticizers, heat stabilizers, ultraviolet light stabilizers, nucleating agents, tougheners, and reinforcing agents.

#### EXAMPLES

25 The examples that follow and corresponding tables further illustrate the present invention.

##### Batch Process

A 5470 lb nylon 66 salt solution, prepared from hexamethylenediamine and adipic acid in water, with a pH of around 8.0 and a nylon salt concentration of  
30 50.85%, was charged into a preevaporator. Then 220 g of a 10% solution of a conventional antifoam agent was added to the solution. The resulting solution was then concentrated to 80% at 35 psia. The concentrated solution was then charged into an autoclave and heated, while the pressure was allowed to rise to 265 psia. Steam was vented and heating was continued until the temperature of  
35 the batch reached 255°C. The pressure was then reduced slowly to 14.7 psia, while the batch temperature was allowed to further rise to 280°C. Pressure was



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then held at 14.7 psia and temperatures were held at 280°C for 30 minutes. Finally, the polymer melt was extruded into strand, cooled, cut into pellets, and dried at 160°C under nitrogen. This polymer, Control 1, also referred to as C1 in the tables, served as the control for data presented in TABLE I below.

5           Using the same batch process and identical amounts of the same reactants used to prepare Control 1, additional polymers were prepared in the presence of a phosphorus compound and base as follows:

10           Example 1 was prepared the same as Control 1, with the exception that 109 grams of sodium hypophosphite monohydrate (SHP) was dissolved in 1 gallon of demineralized water and this solution was added to the autoclave containing the 80% concentrated nylon salt solution.

15           Example 2 was prepared the same as Control 1 with the exception that 109 grams of SHP, 272 grams of potassium bicarbonate ( $\text{KHCO}_3$ ), and 7.6 grams of cobalt aluminate pigment were dissolved in 5 gallons of demineralized water. This suspension (noting that cobalt aluminate pigment does not dissolve in water) was added to the autoclave containing the 80% concentrated nylon salt solution.

          Example 3 was prepared the same as Example 2 with the exception that 544 grams of  $\text{KHCO}_3$  were used (twice the amount in Example 2) instead of 272 grams of  $\text{KHCO}_3$ .

20           The resins were analyzed for molecular weight (RV), as measured in accordance with ASTM D789, and Yellowness Index (YI), as measured in accordance with ASTM D1925 using a Hunter Instrument Model D25M-9. YI is a measure of the degree of yellowness exhibited by a resin. The lower the YI value, the less yellow the resin appears.

25           In the tables below, the following definitions apply:

          "P" refers to phosphorus in SHP;

          "Initial RV" refers to the molecular weight of the sample before solid phase polymerization at 180°C for 3 hours; and

30           "Final RV" refers to the molecular weight of the sample after solid phase polymerization at 180°C for 3 hours.

          The results are summarized in TABLE I. The polymers of Examples 1, 2, and 3, each of which contained SHP, had lower YI values than did the polymer of Example C1.

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**TABLE I**

Eg.	SHP (ppm)	KHCO <sub>3</sub> (ppm)	Cobalt Alum. (ppm)	KHCO <sub>3</sub> /P Ratio	YI
C1	0	0	0	---	5.4
1	83	0	0	0	-4.7
2	83	250	7	2.65	-5.6
3	83	500	7	5.30	-5.9

5 The polymers of Examples C1, 1, 2, and 3 were each subjected to solid phase polymerization at 180°C for 3 hours. The molecular weights (RV) of the resulting polymers were measured and are reported in **TABLE II** below.

10 **TABLE II** illustrates the catalytic effect of SHP and the catalyst deactivating effect of the base (KHCO<sub>3</sub>). Shown in **TABLE II** is the increase in molecular weight of the polymers during solid phase polymerization at 180°C for 3 hours. The larger the RV increase, the greater the catalytic effect of the SHP on polymerization.

15

**TABLE II**

Eg.	KHCO <sub>3</sub> /P Ratio	Initial RV	Final RV	RV Increase
C1	---	50.3	76.9	26.6
1	0	52.0	244.1	192.1
2	2.65	56.0	108.7	52.7
3	5.30	57.1	92.1	35.0

20 To analyze the catalytic effect of SHP, a nylon 66 polyamide was prepared from a nylon 66 salt solution (i.e., hexamethylenediamine and adipic acid in water) containing 83 ppm of SHP and 8.5 ppm of cobalt aluminate pigment using the process described in Example 2, except the base was not added into the nylon salt solution. The polyamide was then melt blended in a 28 mm Werner &

Pfleiderer twin-screw extruder under atmospheric pressure at a temperature of 283°C with sodium carbonate powder ( $\text{Na}_2\text{CO}_3$ ) at levels of 0.00 (Example C2), 0.05 (Example 3-1), 0.10 (Example 3-2), and 1.0 weight percent  $\text{Na}_2\text{CO}_3$  in the polyamide (Example 3-3). The melt was then extruded through a circular die, cooled, and cut into pellets. As an additional control, the polymer of Example C1 was remelted in an extruder at 283°C and then extruded through a circular die, cooled, and cut into pellets. This control is labeled "C3" in TABLE III. The initial RV was then measured for each example.

The catalytic activity of SHP was determined by solid phase polymerization of the polymers at 180°C for 3 hours. The results, summarized in TABLE III below, show that Example C2, which contained SHP without any base, exhibited the greatest RV increase. Furthermore, Examples 3-1, 3-2, and 3-3, each containing SHP and base, exhibited RV increases which were significantly less than the RV increase exhibited by Example C2.

**TABLE III**

Eg.	SHP (ppm)	$\text{Na}_2\text{CO}_3$ (ppm)	Molar Ratio $\text{Na}_2\text{CO}_3/\text{P}$	Cobalt Alum. (ppm)	Initial RV	Final RV	RV Increase
C3	0	0	--	0	49.9	77.4	27.5
C2	83	0	0	8.5	51.5	203.6	152.1
3-1	83	500	5.00	8.5	51.8	106.6	54.8
3-2	83	1000	10.00	8.5	52.5	78.8	26.3
3-3	83	10000	100.00	8.5	49.7	55.4	5.7

#### 20 Continuous Polymerization Process:

A nylon 66 salt solution with a pH of 7.45 and nylon salt concentration of 51.5 weight percent was pumped into a preheater at a rate of 4950 lb/hr, where it was heated from about 41°C to about 55°C. The nylon salt solution was then pumped into a prepolymerizer operating at around 235°C and 225 psia, where it was concentrated to about 90% nylon salt, and wherein the monomers were converted to low molecular weight polymer. This low molecular weight polymeric material was then discharged from the prepolymerizer into a flasher, where the pressure was slowly reduced and the material was then discharged from

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the flasher into a vessel maintained below atmospheric pressure and at a temperature of about 283°C, where removal of water and further molecular weight (RV) increase were effected. The resulting polyamide melt was then extruded through circular die holes at about 283°C, quenched with water, and cut into pellets. The following resins were prepared in this manner with the below-

Example 5-1 was prepared as described above with the addition of 62 ppm of SHP (added as an aqueous solution to the nylon 66 salt solution). Neither base nor pigment was added to the mixture. It is noted that in Examples 5-1 to 5-5, all additions of SHP were in the form of aqueous solutions containing a sufficient amount of SHP to yield the desired amount of SHP (in ppm) in the polyamide.

Example 5-2 was prepared as described above with the addition of 54 ppm of SHP to the nylon salt solution. Additionally, 128 ppm of sodium bicarbonate ( $\text{NaHCO}_3$ ) and 7 ppm of cobalt aluminate pigment were added to the nylon melt just before the die.

Example 5-3 was prepared as described above with the addition of 71 ppm of SHP and 407 ppm of  $\text{NaHCO}_3$  to the nylon salt solution. Additionally, 7 ppm of cobalt aluminate pigment was added to the nylon melt just before the die.

Example 5-4 was prepared as described above with the addition of 82 ppm of SHP and 488 ppm of  $\text{NaHCO}_3$  to the nylon salt solution.

Example 5-5 was prepared as described above with the addition of 8 ppm of SHP and 28 ppm of  $\text{NaHCO}_3$  to the nylon salt solution.

YI values for Examples 5-1 to 5-5 are given in TABLE IV.

Example 5-4, which contained 82 ppm SHP and no cobalt aluminate pigment, exhibited a lower YI value than those examples containing less SHP and no cobalt aluminate pigment (i.e., Examples 5-1 and 5-5). Of the two examples containing cobalt aluminate pigment (i.e., Examples 5-2 and 5-3), Example 5-3 had the greater amount of SHP and also exhibited the lower YI value.

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TABLE IV

Eg.	SHP (ppm)	NaHCO <sub>3</sub> (ppm)	Cobalt Alum. (ppm)	NaHCO <sub>3</sub> /P Ratio	YI
5-1	62	0	0	0	-2.1
5-2	54	128	7	2.48	-2.8
5-3	71	407	7	6.0	-4.8
5-4	82	488	0	6.23	-3.0
5-5	8	28	0	3.67	1.3

5            TABLE V, below, illustrates improved color stability on storage. The examples were initially tested for YI values, packaged in moisture proof bags, and then stored at room temperature. The examples were again tested for YI values at randomly chosen intervals over a period of 174 days. It is shown that the color build-up in Example 5-5 was greater than that of the other examples containing greater amounts the SHP. TABLE V also shows that after 174 days, Examples 5-1, 5-2, 5-3, and 5-4, which contained SHP at the given amount, each exhibited a YI value that was significantly better than the YI value exhibited by Example 5-5.

TABLE V

Eg.	YI Initial	YI 14 Days	YI 28 Days	YI 63 Days	YI 87 Days	YI 112 Days	YI 174 Days
5-1	-2.1	-2.3	-1.8	-1.7	-1.5	-1.6	0.2
5-2	-2.8	-3.4	-2.9	-2.7	-2.7	-2.9	-1.1
5-3	-4.8	-4.8	-4.0	-4.1	-3.9	-3.4	-2.4
5-4	-3.0	-2.5	-2.1	-2.1	-1.4	-1.6	0.2
5-5	1.3	3.7	4.8	4.4	4.8	5.2	9.2

15            TABLE VI illustrates the catalyst deactivating effects of the base (NaHCO<sub>3</sub>). Shown in this TABLE VI is the increase in molecular weight during solid phase polymerization at 180°C for 3 hours. Note that after preparation of each example the initial RV was measured.

20

**TABLE VI**

Eg.	NaHCO <sub>3</sub> /P Ratio	Initial RV	Final RV	RV Increase
S-1	0	52.0	200.8	148.8
S-2	2.48	51.3	157.0	105.7
S-3	6.00	52.3	83.5	31.2
S-4	6.23	53.7	86.5	32.8
S-5	3.67	52.6	87.1	34.5

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**WHAT IS CLAIMED IS:**

1. A process for preparing a polyamide composition comprising polymerizing at least one polyamide-forming reactant in the presence of, or introducing into a polyamide melt,

5 (a) a phosphorus compound selected from the group consisting of

(1) phosphorous acids,

(2) phosphorous acid salts selected from the group consisting of phosphorous acid salts of Groups IA and IIA, manganese, zinc, aluminum, ammonia, and alkyl and  
10 cycloalkyl amines and diamines, and

(3) phosphorous organic esters which undergo hydrolysis in the presence of water to form inorganic phosphorous acids or salts; and

15 (b) a Group IA base selected from hydroxides, oxides, carbonates, bicarbonates, alkoxides, and hydrides,

wherein the phosphorus compound is added in an amount sufficient to yield a phosphorus concentration ranging from 0.097 mol to 1.582 mols phosphorus per million grams polyamide, and the base is added in an amount sufficient to yield a  
20 base concentration ranging from 1.785 mols to 33.325 mols base per million grams polyamide.

2. A process for preparing a polyamide composition comprising

(a) polymerizing at least one polyamide-forming reactant in the presence of a phosphorus compound selected from the group  
25 consisting of

(1) phosphorous acids,

(2) phosphorous acid salts selected from the group consisting of phosphorous acid salts of Groups IA and IIA; manganese, zinc, aluminum, ammonia, and alkyl and  
30 cycloalkyl amines and diamines, and

(3) phosphorous organic esters which undergo hydrolysis in the presence of water to form inorganic phosphorous acids or salts, to form a polyamide melt; and

(b) introducing into said polyamide melt a base selected from the  
35 group consisting of Group IA hydroxides, oxides, carbonates, bicarbonates, alkoxides, and hydrides,

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wherein the phosphorus compound is added in an amount sufficient to yield a phosphorus concentration ranging from 0.097 mol to 1.582 mols phosphorus per million grams polyamide, and the base is added in an amount sufficient to yield a base concentration ranging from 1.785 mols to 33.325 mols base per million grams polyamide.

3. The process of claim 1 wherein the phosphorus compound and the base are introduced into the polymerization process at the same time.

4. The process of claim 1 wherein the phosphorus compound and the base are introduced into the polymerization process at different times.

5. The process of claim 1 or claim 2 wherein the polymerization of the polyamide-forming reactants is by a batch method.

6. The process of claim 1 or claim 2 wherein the polymerization of the polyamide-forming reactants is by a continuous polymerization method.

7. The process of claim 1 or claim 2 wherein the phosphorus concentration in the polyamide is from 0.194 to 1.129 mols phosphorus per million grams polyamide and the base concentration is from 3.571 to 14.286 mols base per million grams polyamide.

8. A polyamide composition prepared in accordance with the process of claim 1 or claim 2.

9. The polyamide composition of claim 8 further comprising at least one conventional additive selected from the group consisting of flame retardants, lubricants, pigments and dyes, optical brighteners, organic antioxidants, plasticizers, heat stabilizers, ultraviolet light stabilizers, nucleating agents, tougheners, and reinforcing agents.

10. A polyamide composition prepared in accordance with the process of claim 3.

11. A polyamide composition prepared in accordance with the process of claim 4.

12. A polyamide composition prepared in accordance with the process of claim 7.



# INTERNATIONAL SEARCH REPORT

Internat Application No.  
PCT/US 94/01585

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 5 C08G69/28 C08K3/22 C08K3/26 C08L77/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 C08G C08K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 089 (C-411) 19 March 1987 & JP,A,61 243 827 (TORAY IND INC) 30 October 1986 see abstract ---	
A	DATABASE WPI Section Ch, Week 7440, Derwent Publications Ltd., London, GB; Class A23, AN 74-70421V & JP,B,49 033 593 (ASAHI CHEM IND CO LTD) 7 September 1974 see abstract ---	
A	FR,A,2 229 731 (I.C.I.) 13 December 1974	
A	& US,A,4 237 034 (J.H. TOMKA) cited in the application ---	
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

28 June 1994

Date of mailing of the international search report

22. 07. 94

Name and mailing address of the ISA

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## INTERNATIONAL SEARCH REPORT

Internati

Application No.

PCT/US 94/01585

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 352 821 (W. COSTAIN ET AL) 14 November 1967 -----	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat

Application No

PCT/US 94/01585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-2229731	13-12-74	AU-A- 6837074	30-10-75
		BE-A- 815018	14-11-74
		JP-C- 1234346	17-10-84
		JP-A- 50032251	28-03-75
		JP-B- 59008300	23-02-84
		CH-A- 603742	31-08-78
		DE-A, B, C 2420681	05-12-74
		NL-A- 7406388	18-11-74
		US-A- 4237034	02-12-80
US-A-4237034	02-12-80	GB-A- 1465046	16-02-77
		CH-A- 603742	31-08-78
		DE-A, B, C 2420681	05-12-74
		NL-A- 7406388	18-11-74
		AU-A- 6837074	30-10-75
		FR-A, B 2229731	13-12-74
		JP-C- 1234346	17-10-84
		JP-A- 50032251	28-03-75
		JP-B- 59008300	23-02-84
US-A-3352821		BE-A- 636917	
		CH-A- 430192	
		FR-A- 1375870	
		GB-A- 997316	
		NL-A- 297427	